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UNITED STATES DEPARTMENT OF AGRICULTURE
 BUREAU OF ENTOMOLOGY
 WASHINGTON, D.C.

Mediterranean Fruit Fly Survey in Europe and Africa.

Introductory Note.

In connection with the investigation of the Mediterranean fruit fly in Florida, in 1929, the need was recognized of up-to-date information on the behavior of this insect in Mediterranean, South African, and other countries where it had been long established. About that time Mr. Allison V. Armour, of New York, advised me of his desire to place at the disposal of the Department for such survey work a vessel --the "Utowana"--which he had specially equipped for biological or other scientific surveys. It was at once appreciated that with such means fairly wide surveys, particularly as to Mediterranean countries, could be made in much less time than by the ordinary means of travel and with much improved facilities, and Mr. Armour's offer was promptly accepted. Dr. H. J. Quayle, professor of entomology of the University of California and entomologist of the Citrus Experiment Station at Riverside, was selected for this work. Dr. Quayle had previously been drafted by the Secretary of Agriculture as a member of a special committee to study and report on the fruit-fly work in Florida, and was therefore familiar with the situation in that State. He had also, some 15 years earlier, made at my request a reconnaissance survey for the Bureau of Entomology in the Mediterranean region during one of his sabbatical years, resulting in a bulletin, published by the Bureau, giving valuable data on the Mediterranean fruit fly and other citrus pests.

The work conducted under the aid of Mr. Armour was carried out between August 26 and November 16, 1929. The cruise of the Utowana started from New London, Conn., and, en route across the Atlantic, afforded opportunity for surveys and work at Bermuda and the Azores. It reached Gibraltar September 16. The balance of the period, to November 16, was spent in visiting the important countries and points throughout the Mediterranean section--the cruise ending at Naples. Dr. Quayle then returned to Valencia, Spain, perhaps the most important orange district from the fruit-fly stand-point, and continued his studies there from November 19, 1929, to January 3, 1930.

The next three months were spent in a trip to South Africa for study of the fruit-fly situation there, covering the important period of fruit-fly activity between January 27 and March 28. Dr. Quayle returned to Spain in April, 1930, and supplemented his work there of the previous season by investigations covering the period between April 23 and June 9.

This work of exploration was carried out in cooperation with the Plant Quarantine and Control Administration, and all expenditures, other than those concerned with the cruise of the Utowana, were under authorizations of that Administration. The services of Dr. Quayle were made possible by the cooperation of the University of California. Dr. Quayle's report is being issued in this form to make it available to persons immediately concerned in fruit-fly work.

C. L. Marlatt,
Chief, Bureau of Entomology.

Report of a Survey of the Mediterranean
Fruit Fly, *Ceratitis capitata*.

By H. J. Quayle.

The inspiration for the present survey came in July, 1929, when Mr. Allison V. Armour generously placed his yacht Utowana at the disposal of the United States Department of Agriculture for the purpose. Arrangements were made between Mr. Armour and Dr. C. L. Marlatt, Chief of the Bureau of Entomology and of the Plant Quarantine and Control Administration, for a survey of the biological and economic aspects of the fly, particularly in the Mediterranean region where the fly has been known to occur for about 100 years.

The yacht was especially equipped with a laboratory, photographic room, and office and library, thus making it possible to collect material at the different stops and place it in breeding jars for the rearing of specimens. The laboratory tables made possible the use of the microscope for the examination of material. Such means of transportation proved to be most desirable in enabling visits to be made in quick succession to the different countries and thus comparisons made of the status of the fly in the different places at about the same time. Upon arriving at Gibraltar the writer made out a schedule for the places and time of stops and this was carried out practically to the letter during the two months' cruise around the Mediterranean.

Log of the cruise of the Utowana,
Aug. 26 to Nov. 16.

The yacht left New London, Conn., on August 26th, 1929. The first stop was made at Hamilton, Bermuda, August 30 and 31. One half day was spent with Mr. McCallan, director, and Dr. Cunningham, plant pathologist and entomologist, in and about the experiment station, and the rest of the time with Dr. Cunningham in a trip over the Islands looking for the fruit fly. Fruits generally are scarce in Bermuda at this time. There was an occasional Surinam cherry of the second crop remaining and a few sapodillas. Larvae of C. capitata were taken in these fruits. Peppers were examined and collected in several places and larvae much like C. capitata were seen, but all of the flies bred out of the peppers collected were species other than C. capitata. Citrus fruits, including grape fruit, oranges, limes, and lemons were examined in several places but all were free from the fly because of immaturity, since they were all quite green in color and had not reached full size.

The fly seems to be of no great importance to the horticulture of the Islands at the present time. The chief export crops are not attacked, with the exception of peppers, which possibly are slightly infested. Very few peaches are grown on the Islands, possibly on account of the fly. But peaches would not likely be grown on the Islands to the extent of an industry, because

the climatic conditions are not the most suitable for the peach, and besides the competition could not be met with the United States. Certain citrus, as grapefruit and limes, would be much more suitable crops than peaches under Bermuda conditions, yet such fruits are not grown extensively. Available land for such crops is limited, and the competition is too keen from the neighboring islands to the south.

An eradication campaign against the fly in Bermuda would not meet with any general approval; particularly for the reason that the fly is not considered to be a sufficiently serious pest. The Surinam cherry, which grows in thickets in the wilds, would be one of the most important hosts to eliminate. However, the eradication of the fly from the Islands would be a small job as compared with that of Florida. A list of the more important hosts in Bermuda would include the Surinam cherry, guava, sapodilla, and citrus.

On September 9th and 10th a stop was made at Ponta Delgado on the island of San Miguel of the Azores. In company with Mr. Francisco Co-gunbreira a trip was made over a part of the island with stops for the inspection of apples, pears, peaches, figs, grapes, and persimmons. No evidence of the fly was seen during the first day. The fruits are limited to a few trees growing in gardens, with the exception of grapes. Corn is the staple crop of the island and is grown everywhere. No wild fruits were observed. Pineapples are grown on an extensive scale under glass, and this is the only fruit that is exported. Oranges are very scarce, being restricted to a few trees in gardens.

The next day several gardens within the city were visited, including Mr. Cogunbreira's own extensive garden nearby. All of the fruits mentioned above were again seen but the only infestation discovered was in one lot of pears. Climatic conditions seemed favorable for the fly and such susceptible fruits as the peach were present, yet the fly was very scarce. This is probably due to the fact that there is not a sufficient sequence of hosts to carry the fly in large numbers throughout the year.

September 16th to 20th was spent at Gibraltar, this time being necessary to carry out certain repairs to the ship, since there was little to see here aside from the markets. These were visited each day including one day at Tangier, Morocco, and peaches were easily found that were infested as well as an occasional pear, but figs and other fruits were free.

Five days, September 22nd to 26th, were spent at Valencia, Spain. During my stay here I was shown about by Mr. Carlos Escriva who was my interpreter seven years ago and who has since been in the employ of the American Cyanamid Co. Through the courtesy of H. W. McCoy, in charge of this Company, Mr. Escriva and his automobile were placed at my service, and the territory for a range of about 50 miles around Valencia was well covered. This was the first extensive orange district visited, and one of

the important points on which information was needed was the time the flies first attack the orange as it is approaching maturity. I happened to be successful on the first day out in finding a few prematurely colored fruits of the present season's crop with punctures of C. capitata. These were not so-called off-bloom fruits. They were of fairly uniform color and were no larger, in fact some were smaller, than the green fruit on the same tree. The pulp was of light green color, but in a few cases the pulp was yellow and not unpleasant to eat, which indicated considerable maturity. Some of these more mature fruits when examined later in the laboratory, were found to contain larvae of C. capitata. About a box of such fruit was collected during the 5-days' stay at Valencia and after examination was placed in breeding jars to determine if any of the larvae might mature; 14 adults were later secured from this lot. Several of the prematurely colored oranges would have typical egg-punctures but there would be no eggs. Many others contained eggs and these later hatched but the larvae did not succeed in getting out of the egg cavity.

Such colored fruits as mentioned were taken only on very occasional trees, but on these occasional trees there might be a considerable number of such fruits some of which were on the ground. The coloring was not due to the punctures of the fly for the reasons that the coloring was uniform, that only an occasional tree would have such fruit, and that many such colored fruits had no punctures. The punctures, therefore, followed the coloring.

Some oranges on certain trees mature early naturally, but those indicated above would not come in this category. These were small and tended to drop from the tree. One definite cause of such early coloring and dropping was guming. Such fruits had an accumulation of gum, dark in color, in pockets just beneath the surface. This guming was not associated with trees having gomosis or psoriasis. Growers claimed it was due to too much water.

All of these prematurely colored fruits were found in the Plana district to the north of Valencia, which is not the earliest orange district. In the Ribera to the south of Valencia, which is supposed to be the earlier district, while much of the fruit was larger, I happened upon no fruits that were prematurely colored and found no fruit with fly punctures in this district.

The information secured here indicates that oranges may be attacked by the fly in September, as early as the middle of September. The extent of infestation was of course very slight and of no commercial importance, but very important in any consideration of eradication measures. This applies to the present maturing crop. Off-bloom or other fruits that may be mature are liable to the attack at any time when the fly is active. A half dozen or more of such fruits were found with nearly full grown larvae of C. capitata.

A visit was made to one of the sections where there are more or less peaches, Ontoniente, about 50 miles from Valencia, and 30% of the peaches still remaining on the tree were infested.

At Palma on the island of Majorca four of last year's oranges grown at Soller were found infested on September 27th.

Algiers was visited on September 29th-30th and a trip was made to the citrus section of Boufarik about 20 miles from Algiers. There were many mandarins here as well as oranges, but they were all green and no infestation was seen. The only other fruits were pomegranates, a few pears, and some crab apples. Dates were observed also but no infestation was noted in any of these fruits. In the market at Algiers, however, infested peaches and a few pears were taken.

October 3rd to 9th was spent at Naples and vicinity including Sorrento and Amalfi. A few of last year's oranges were found infested at Sorrento and infested peaches were taken at several places. No fruit of the present crop of oranges was infested. While here I spent some time with Prof. F. Silvestri at Portici, who very kindly gave me a place to work in his laboratory and gave me much information from his wide experience with the fly.

At Palermo, October 10-11, inspection of citrus groves around Monreale and Bagheria failed to show any infestation, and by this time all of the peaches were harvested; but a few infested ones were seen in the Palermo markets.

Malta, October 13-14, was the first place where the adults were very common on orange trees, and many fruits were already attacked. This was in the San Antonio garden a few miles out from Valetta. The gardens were well sheltered and a large variety of fruits are grown. These conditions resulted in the early maturing of the oranges and a good supply of flies. The flies were seen ovipositing on some of the fruits which were attaining a distinctly yellow color. In a few cases rather green fruits were attacked and the punctures caused a yellow spot. As these fruits' color generally the area about the puncture appears greener since it does not continue to color with the surrounding area. Here as at Valencia there were strings or punctures with no eggs or where the larvae had not reached the pulp.

Mr. J. Borg, superintendent of agriculture for the islands, took me to the gardens where we met Mr. John Briffa, the superintendent. There was a large jujube tree in the gardens and Mr. Borg stated that he had bred C. capitata from the fruits. If this is authentic it may be a new host record. Back states that the jujube is not attacked in Hawaii. Mr. P. Borg, a brother, is the entomologist and plant pathologist and he has been using carbon disulphide in the soil to kill the pupae, claiming that the bait spray is not effective.

At Syracuse, October 15-19, several orange groves were visited to the north of the city and much the same situation was observed here as at Malta. That is, some of the fruits were turning yellow, flies were seen on some of the fruits, and fruits were collected that had punctures, and a few with young larvae. There was a small lot of new oranges on the Syracuse market. In one grove shallow earthenware vessels were seen in occasional trees which contained a bait used for the olive fly, Dacus oleae.

During this stop adults began to emerge from cages in the ship's laboratory from oranges of this year's crop collected at Valencia, Spain, Sept. 22-26. The cruise of the western Mediterranean was completed at this point.

The yacht landed at Port Said on October 24th and the same day a train was taken for Cairo. The day following, being Friday and the Egyptian Sunday, I was fortunate in meeting Mr. E. H. McComber of the American Cyanamid Co. thru whose courtesy I was able to visit orange gardens in the vicinity where he was carrying on fumigation experiments. The next day I visited the Ministry of Agriculture and called first at the Plant Protection Service in charge of Mr. E. Ballard. Mr. Shaw was in charge in Mr. Ballard's absence, and he soon put me in touch with Mr. R. I. Nel who was working on the fly as a special problem, and much of the remainder of my stay was spent with Mr. Nel. I later met the Minister of Agriculture and also received much assistance from Drs. Kamal, Baghat, and Solomon of the Dept. of Agr. and Dr. Efflatoun Bey of the University of Cairo.

With Mr. Nel I visited a number of orange groves to the north of Cairo, and a few oranges were seen with stings and one or two flies seen on fruits. This was the extent of fly evidence I saw in Egypt up to Oct. 28th. Mr. Nel had secured some oranges from an earlier district that were more mature and some of these were infested. He stated that the fly is more or less active throughout the winter in Egypt, and later in the season, December, there may be considerable infestation. I saw Mr. Nel in South Africa latter and he said that in some places there was a rather heavy infestation in mandarins and in oranges in restricted places. The only larvae of C. capitata seen in the field were in guavas. In all of the citrus visited the fruits were still green, which accounted for the slight infestation at the time.

The orange plantings in Egypt in the vicinity of Cairo are for the most part widely scattered with corn or cotton predominating between them. In many cases, too, there are no other fruits nearby. Under such circumstances a heavy infestation in citrus would not be expected. Where other fruits do occur the infestations in restricted areas observed by Mr. Nel would be accounted for. The fly is not likely to carry over for long periods in the pupal stage in Egypt because of the high temperatures. Where there is not a sequence of hosts, therefore, the carry-over would be as adults, and no doubt with sufficient food they could maintain themselves for long periods.

Peaches are not grown extensively in Egypt and the fly might well be the limiting factor. The season was not opportune for determining the infestation in deciduous fruits. Apricots and plums are grown to some extent and these fruits are commonly infested. Dates are not infested, according to Mr. Nel, and I saw none here or in Algiers. An outfit was seen in one place where they were making the first application of the bait spray on citrus, by means of knapsack sprayers.

From Cairo I took the train to Palestine, Oct. 30-Nov. 1, going first to Jerusalem to see Mr. G. E. Bodkin, the government entomologist. He had one of his assistants accompany me by auto the next day for the inspection of orange groves in the vicinity of Jaffa. Here I met Mr. A. C. Turner and Mr. S. Antabi of the Dept. of Agr. The latter kindly furnished the automobile for the day and in company with Mr. A. Friedman, Agriculturist for the Palestine Jewish Colonization Association, I visited fruits, chiefly oranges, about Jaffa and Tel-Aviv. The Mikveh-Israel agricultural school and fruit plantings were also visited and I was shown over the grounds by the director, Eli Krause, and the superintendent of plantings, Mr. Yedidiah.

The oranges in Palestine were more mature both as to color and its size than in Egypt. Punctures were seen in some of the yellow fruit and one or two had small larvae. Around Jaffa and Tel-Aviv there are large areas planted solidly to oranges and this condition may be more favorable for the fly than the more scattered plantings of Egypt. Here again few peaches are grown, probably on account of the fly. There are plantings of apricots and these suffer from fly attack. On account of the early harvesting of apricots these may be grown whereas peaches cannot because of the later harvesting as well as the greater susceptibility. Where mixed fruits occur, as at the Mikveh-Israel school, there is heavy infestation in some of the fruits.

At Cyprus, Nov. 4-5, the earliest oranges were seen and the first shipment was being made. By this date, however, the first oranges may have gone out from some of the places previously visited. Famagusta was the port of call and there is a considerable acreage of citrus in this vicinity. A few oranges were attacked by the fly at this point and from a couple of fruits I succeeded later in rearing the fly in the ship's laboratory. A visit was made to the capital, Nikosia, to see the Director of Agriculture, Mr. T. Dawe. Mr. Dawe was away for the day but I met the Entomologist, Mr. H. M. Morris. The Governor, having heard of our visit, directed Mr. H. B. Usher, who was then at Famagusta, to show me about the plantings at Famagusta. Considerable shipments of oranges are made from this island to Egypt.

A day's stop was made at the island of Rhodes, Nov. 8th. This year's oranges were rather common in the market and were well infested with the red soft scale but no infestation of the fly was noticed. The orange plantings were too remote from the port to be visited in the time available.

On November 13th the yacht returned to Naples, having to put in here instead of going on to Valencia on account of the illness of one of the guests. On the 16th I left for Valencia, Spain, by train. The cruise of the Utowana was thus ended at this point.

Spain, Nov. 19 to Jan. 3,
and Apr. 23 to June 9.

When I returned to Valencia on November 19th I had no difficulty in finding the adults on the orange trees as well as infested oranges. But the flies were not abundant, there being only one or two here and there. Likewise only occasionally was a fruit found infested. Evidence of punctures was much more common than fruits actually infested with larvae. It was difficult to make an estimate that would be much better than a guess as to the amount of infestation. In some counts of picked fruit, including those with punctures and not actually infested, the amount ran about 1%. Taking all of the crop I do not believe the infestation would exceed that figure. On some trees, however, the infestation would be greater and would reach about 5%. No special effort was made, so far as I could see, to cull out such fruit.

to 27th

A trip was made to Madrid Nov. 24th and while there I consulted with the Entomologist of the agricultural school, and also saw the Minister and Director of Agriculture, and the Premier. Dr. de Torres stated that the fly was known to attack apricots near Madrid.

On Dec. 6th and 7th an inspection of the Murcia citrus area was made in company with Mr. Benlloch of the agricultural school of Madrid, who was sent here at the request of the Minister, and Mr. Arroniz the local agriculturist. This is a warmer section than Valencia, but there was no great difference in the general fly situation. The citrus area of this district was well covered in the two days spent here. Apricots are extensively grown in this area, and it appears to be the world's center for pimento peppers.

Adults were seen on orange trees up to the time I left on January 3rd. They were much more difficult to find late in December and early in January, than earlier, indicating that they were disappearing for the winter. During this time there were a few nights when the temperature went to freezing, but an occasional fly would be seen on the following day on the warm side of the tree. December, 1929, at Valencia was characterized by warmer and drier weather than normal. While flies were seen on the trees during the month, after the first week I saw no evidence of eggs being deposited, and there were no young larvae taken in the fruit after that time. An unusually warm period might induce them to deposit eggs later, and, on the other hand, a cold wet December might cause all of the flies to disappear.

Several hundred flies confined in an open screen insectary died toward the end of December, but lack of proper feeding may have been partly responsible for the mortality. Larvae collected in December and which had pupated did not transform to the adult before I left on Jan. 3rd. These were in three inches of soil in glass jars in the screen insectary. The jars were sunk to a depth of three inches in the soil and this soil was raised one foot above the general surface. The insectary was located on the south side of a stone wall. The conditions, therefore, would be about the warmest occurring naturally.

When I returned to Valencia Apr. 23rd all of the pupae had transformed to the adult and these were dead in the jars. There were 47 in one jar and 34 in the other. Mr. Simpson of the American Cynamid Co., on whose premises the insectary was located, had made notes to the effect that on Feb. 1st 3 live flies were seen; 1 on Feb. 6th; 1 on Feb. 10th; and 1 on Feb. 28th. There was no food in the jars. If the flies do not live longer than four days without food, as Back has determined, some of these flies must have been in the pupal stage from the middle of December to the last of February. If this length of time may be spent in the pupal stage under the warmest natural conditions for this district, it is most likely that pupae in the coldest situations would survive the entire winter and emerge in the spring. This would occur particularly in localities having a colder winter than that of Valencia, Spain. Two adults emerged on January 2nd from fruits kept in my room in the hotel which was steam heated. Thus in countries warmer than Spain, as in Egypt, flies may continue to emerge throughout the winter.

When I returned to Valencia in the spring, Apr. 23rd, I was unable to find any flies, and there was no evidence that any fruits had been attacked during the winter. Oranges were present in great numbers and in condition to be attacked by the fly had any been about and active. In April and May loquats were common and the mature and up to the middle of May no evidence of the fly was seen in this fruit. Frequent inspections were made in the field at Valencia up to the 23rd of May but I didn't happen to find any loquats, or ^{apricots} oranges, the prevailing fruits at the time, infested, and I saw no adults on the trees. There were very few orange groves where the fruit was not picked by May 23rd, and in another week or two no fruit would be left. Such fruit as was present at this time was overmature, many soft and many already fallen, an ideal situation for fly attack had the fly been present and active.

I left Valencia on May 27th and spent the 28th at Murcia, a location that is more interior and where the summers are hotter than at Valencia. I succeeded here in finding oranges infested with full grown larvae of C. capitata. Adults must have been about here early in May. I happened to get these infested fruits from a lot that had been culled from two cart loads that had just come from the field. Two or three larvae were taken in each of five fruits out of the three dozen culles, and they were all mature larvae. Much fruit was present here but no further infestation was seen in oranges. Two or three larvae were taken in a lot of culled loquats and a similar number in apricots. At Malaga I found a few apricots infested but found nothing in oranges. The larvae in apricots were quite small. Malaga has as mild a winter climate as any place in Spain and I expected to find more evidence of the fly there. At Seville a few days later I didn't succeed in getting any infested oranges or apricots. On account of rains my inspection was limited here to the markets, but the market is usually a good place to find infested fruits. All of the oranges about Malaga were harvested and this was true also for the sour oranges of Seville.

From the observations made in April, May, and the first days of June from Valencia to Gibralter, I would say that the fly may appear in the earliest districts, as Murcia and Malaga, as early as May 1st and at Valencia not until about June 1st. There might be an occasional fly at

Malaga any time during the winter. Only sporadic infestations may occur in May and early June, and as a pest the fly may be ignored up to this time. All of the loquats and oranges and most of the apricots in the district covered are harvested before the fly becomes numerous enough to be serious. These fruits are the only important hosts at this season. The first figs mature early in June, and later in the month the first peaches. It is not before July that the fly becomes a pest of any consequence in Spain.

South Africa, Jan. 27 to Mch. 28, 1930.

I reached Capetown on January 27th and until February 13th the time was spent in Capetown and in the deciduous fruit districts of the western part of the Cape Province. While at Capetown, I examined, with Dr. F. W. Pettey, several lots of fruit, mostly peaches, that had been in cold storage for the purpose of destroying the younger stages of C. capitata. A separate report has been submitted on this work, the gist of the results being that a predominating minimum fruit temperature of 30 degrees F. for 7 days did not effect a complete mortality, but that with a predominating minimum fruit temperature of 32 degrees F. for 21 days no larvae or pupae survived.

With Dr. Pettey most of the important fruit districts of the western Cape were visited, including Elsenburg, Stellenbosch, Drakenstien, Pearl, Wellington, Worcester, Hex River, Somerset West and Elgin.

C. capitata is primarily a pest of peaches and nectarines in this district. Other fruits are attacked but the fly is not considered a serious pest on these. The commercial peach orchards, as well as the few nectarines there may be, are very consistently treated with the bait spray. As a consequence of this control work the fly is kept down to a minimum, and where this is systematically and thoroly done there is practically no injury done by the fly. It was often difficult or impossible to find infested fruit in the commercial plantings, but in gardens nearby or in any neglected area infestation was common. I was impressed with a statement made to me later by Professor Lounsbury that C. capitata is primarily a pest in the towns and about households. This was observed to be the case in many striking instances in the western Cape Province and elsewhere. It is due not only to the fact that the fruits in gardens are not treated, but also to the fact that there are usually a variety and sequence of hosts on which the fly may increase throughout the breeding season. In some of the commercial plantings I assumed that the fly was not common in the district anyway, but a visit to nearby gardens, particularly where there were peaches, would generally convince one to the contrary.

Deciduous fruit growing for export in the western Cape is a highly specialized industry. Nowhere in the world is greater care taken for the production of quality fruit, both as to the culture and to the handling and marketing. Quality rather than volume is what the growers of export fruit strive for. This is necessarily the case, for otherwise the fruit would not survive a 6,000-mile journey which takes it thru the tropics. Moreover, there is plenty of cheap labor to do all of the hand work that is necessary. Each of the individual fruits or bunches of grapes is gone over by hand, wrapped and packed separately in a liberal supply of wood wool or excelsior, and usually in boxes with but one layer of fruit. Such fruits as peaches, plums, and grapes are picked from the tree and placed on shallow basket-like trays with only one layer of fruit, sometimes each fruit in a separate nest,

and thus carried to the packinghouse. With such careful growing and handling the amount of fly infestation is reduced to a minimum. All of the growers questioned in this district expressed themselves as highly satisfied with the results of the poison bait spray.

From Capetown I went to Pretoria which is the headquarters for the Union of the Department of Agriculture officials. When I arrived at Capetown I met the Minister and Secretary for Agriculture, Gen. J.G.C. Kemp, and Col. Williams, and they arranged my itinerary, with Dr. F.W. Pettey at Capetown and thru Dr. I.B. Pole-Evans, Dr. T.J. Naude, and Dr. H. Hahne at Pretoria.

The first trip out from Pretoria was a two-days' trip with Professor Lounsbury and Dr. Naude to the Rustenburg area about 75 miles west of Pretoria. The adults of the Mediterranean fruit fly were scarce on the citrus trees and the first fly I saw didn't look quite natural, and upon capturing it it proved to be the Natal Fly, Fterandrus rosa, which was a new record for that area. One or two others of the same species was later captured in the same grove. Punctures were seen on some old fruits, but as all of the present crop was green no work of the fly was seen.

The second trip was made to Nelspruit, White River, and Barbeton about two hundred miles to the east. On this trip I was accompanied by Dr. H. Hahne, senior horticulturist, and when we arrived at Nelspruit we were joined by M.M. Mathew, in charge of the citrus and subtropical station, Mr. Esselen, horticulturist, and Mr. Anderson, entomologist. Citrus, mangoes, and papayas were the chief fruits inspected here, and, aside from a few mangoes, fly infestation was not seen. All of the oranges were too green and it is only the ever-ripe papayas that are occasionally infested. Infestation in oranges is said not to occur in the general area of the Transvaal until late in May or in early June. A unique experience on this trip was a visit to the Kruger National Park on Saturday afternoon and Sunday where many of the African wild animals were seen in their native haunts.

The next trip from Pretoria was made to the Zebedeila Estates 200 miles to the north where there are 600,000 citrus trees, the largest single planting in the world. Dr. Redvers J. Blatt, resident manager, met Dr. Hahne and myself at Tetgietersrust, twenty-five miles from Zebedeila, drove us to the Estates, and showed us about the extensive plantings. While there was no fly seen Dr. Blatt told us that it was one of their citrus pests but that he handled it satisfactorily by spraying.

The fourth and last trip from Pretoria was made with Dr. Naude and Dr. Hahne to Vereeniging on the Orange Free State border about 80 miles to the South and thus was covered the territory in the four cardinal directions from Pretoria. This was a trip for the inspection of apples, since this was the chief fruit left in this territory. No infestation was seen during the day although some of the apples were mature. The orchards are widely scattered and the growers didn't consider the fly as a pest. Possibly the frequent arsenical sprays which are applied succeed in checking the fly as well as the codling moth.

In the city of Pretoria peaches were infested earlier, but it was at

the end of the peach season. Other fruits are also infested in the gardens and before I left the ripening quinces were commonly infested.

Upon leaving Pretoria the next stop was made at the Agricultural School at Cedara in Natal, where two days were spent with Dr. I. F. Ripley who is carrying on an extensive investigation on the Natal fly, Iterandrus rosa, particularly with reference to repellents, attractants, and obscurants. Ripley stated that this species is the limiting factor to fruit growing in that area. On the station grounds there seemed to be nearly 100% of the apples and pears infested. A dozen or more stings were observed on single fruits. Nothing has been done to control the fly because the orchard was used as a source of supply for the experiments. However, the poison bait spray, or Mally bait, is entirely ineffective against this species under the conditions at Cedara, as determined by Ripley some years previous. He made 30 applications of the Mally bait on a block of trees on the school grounds during one season and the fruit on this block had a 56% infestation, which happened to be exactly the same amount as was on the check plot. Ripley attributes the failure of the spray to the moist climate. Cedara is in the mist, we call it fog, belt. Nearly every day, as was the case during my stay, a dense fog appears in the afternoon and foliage is dripping wet. In addition in the summer when the fly is active there are frequent rains. Ripley's explanation is that the rains and fog not only wash off the spray, but that some conditions furnish abundant drink which the fly can get anywhere and so is not dependent upon moisture supplied by the spray. I brought up the question of the possible resistance of the Natal species to the spray but he had no information on that point and promised to make some tests. I cited the apparent success in Florida in spite of rains which are probably heavier there than at Cedara, but the fog represents rather a different factor at the latter place.

C. capitata does not occur at Cedara but it does occur lower down along the coast. The elevation at Cedara is 3700 feet and there are two or three distinct mist belts which run parallel with the coast, Cedara being in one of these. Along the coast, as at Durban, both C. capitata and I. rosa occur, but curiously there rosa attacks cultivated fruits chiefly while capitata attacks wild fruits chiefly. Ripley as well as Van der Merwe are responsible for this statement. It is interesting that presumably the native species attacks the cultivated and the introduced species the wild fruits. But Ripley is not sure that Natal is the native home of the Natal fly. It may be possible also that the Mediterranean fruit fly is indigenous to eastern as well as to western equatorial Africa. Natal, while not strictly within the tropics, has a tropical climate along the coast, at least in summer.

Climatological data kindly furnished by W. J. Hall, Observer at Cedara, indicate that the minimum temperature at Cedara may be as low as 26°F. The Natal fly disappears there during the winter. Ripley found some evidence of adults surviving the winter last year in a grove of eucalyptus trees. According to Ripley either capitata or rosa occurs at Middleburg in the Transvaal in Griqua Land East, and in Natal, where there may be temperatures as low as 5-10 degrees F. The most important wild host in the vicinity of Cedara is Solanum articulata. This Solanum has fruits about the size of marbles and these were just beginning to mature when I was there in March. It is an important carry-over host and should be destroyed, according to Ripley, if fruit growing should be attempted on a commercial scale.

But climatic conditions, at least at Cedara, are not suitable for fruit growing. It is essentially a country for dairying or other industries dependent upon pasturage. It is also well adapted to the growth of the black wattle for tannin. Mr. John Fisher is the Principal of the Cedara agricultural school and its hospitality was extended to me during my stay.

At Port Elizabeth, March 16-20, I was with the government entomologist located there, Mr. D. Gunn. Trips were made to Uitenhage and to the Sunday's River Valley. This general country has in many places a thick growth of prickly pear, and I was interested to know if the presence of this wild host increased the infestation in the cultivated hosts growing nearby. At Uitenhage the estate of Sir Percy Fitzpatrick, Amanzi, was visited. We were met at the train by his manager, Mr. Johnson, and between the town and the Estate a distance of 10 or twelve miles, it is all native bush with much prickly pear in places, and pear immediately surrounds the plantings. They have some trouble with the fly and treat for it, but so far as I could determine it is no worse than in other areas where the pear is not present. They were considering the desirability of eradicating the pear immediately about the plantings of citrus. But since it would be a large undertaking it would be very questionable if it would pay, because the spray treatments would no doubt have to be continued anyway. The fruit of the prickly pear was just beginning to ripen and it was not the most opportune time to determine infestation, but such ripe fruits as were examined showed no work of the fly. Mr. Gunn made a count at one time of a quantity of dropped, and consequently well ripened, fruits, and about 1% of these were infested. Counting the total crop there would be a very low percentage of infestation.

In the Sunday's River valley several citrus groves were visited and at one place inspection was made in grapes, but there was no infestation observed. All of the oranges were immature. This area and Uitenhage are not a very great distance from the coast and whether this was the explanation or not there didn't seem to be quite as uniform satisfaction with the bait spray. Mr. Gunn had carried on experiments at Bathurst some years ago and came to the conclusion there that the spray was not effective. Bathurst is immediately along the coast.

When I returned to Capetown on March 23rd I examined the last lot of fruit that had been placed in cold storage to kill the younger stages of the fly. At this time it was getting well toward the end of the grape season and was an opportune time to observe infestation in grapes. Such infestation was found in a few places but not a very large amount. The heaviest infestation seen was on the government wine farm at Pearl. Here on the Ohanez variety the amount might reach 1% or 2%. Infestation was most readily detected on this white grape, and was characterized by darker and irregular streaks, indicating the course of the larvae, just beneath the skin. Infestation was also observed in the Hannepoort and Gros Colmar varieties.

On March 28th I sailed from Capetown for Southampton on the S. S. Arundel of the Union Castle Line. As indicated in my report on cold storage I kept some tab on the temperatures maintained in the chambers containing the export fresh fruit. It appears possible to keep any certain temperature as low at least as 30 degrees F. with a variation of but one or two degrees.

The Mediterranean Fruit-Fly,
Ceratitis capitata Wied.

Distribution.

The Mediterranean fruit fly has been recorded as attacking apricots in the environs of Paris, and de Torres of the agricultural school at Madrid states that it has been taken on the same fruit near Madrid. These points probably represent the northern limits of distribution in Spain and France, and are really farther north than the area where it is a pest of any consequence. The fly occurs as a pest chiefly in the southern part of Spain and along the coast in France and Italy as far as Naples from which point south it may be a pest in the interior. Silvestri states that it is not a pest northward from Rome in Italy, and that it is important only along the coast. It occurs in Greece, Syria and Palestine, in Egypt and northern Africa, and on most of the islands of the Mediterranean. It is generally found in the Union of South Africa but there are areas where it does not occur, as at Cedara in Natal. In the coldest area, as Paris, the fly may be present for a short summer season; at Valencia its season may extend from June to December, while in Egypt it may be present thruout the year. Cold winters definitely limit its distribution, while less cold winters limit its destructiveness within the area of distribution. Climatological data (Will send later. Q.) are appended of certain places to illustrate this. From its distribution in Europe it may be inferred that the fly would be a pest at least in the southern tier of our own states, and possibly well up toward the Ohio river, and on the Pacific coast as far north as Oregon and possibly Washington.

Host Plants.

In countries having a subtropical climate like that of the Mediterranean region and South Africa the peach is the outstanding host. Its ally, the nectarine, is also very susceptible to attack. Following those the writer would be inclined to put citrus if citrus is mature during the active season of the fly. Figs are more susceptible than apples, partly, possibly, because the pear matures earlier than the apple. There are, of course, very early apples and very late pears. One of the predominating fruits in gardens in the Mediterranean region is the fig, but not a single one happened to be found infested on this trip. The fig is not a preferred host. Neither is the date. Quinces were commonly infested in Pretoria in March. Borg of Malta said he reared C. capitata from the jujube, which may be a new host record. Late apricots seem to be commonly infested. The season is just now beginning at Valencia, but thus far, May 21st, none are infested and the fly has not yet appeared. I expect to find the fly farther south where the season, including apricots, is more advanced. In warmer countries, Egypt, the fly is no doubt active as soon as the apricots begin to ripen, and thus the fly would be an important pest. At Valencia a good portion of the crop is likely to be harvested before the fly gets a good start in the spring. (Pencil note in margin - Loquats infested).

The commonest of the wild hosts that grows in close proximity to cultivated fruits in arid regions, as the Mediterranean, is the prickly pear. It is also common in parts of South Africa. It is not a preferred

host, and is only occasionally infested. The destruction of this host as a means of protecting nearby cultivated fruits would not be a practicable procedure for control but would probably be justified in eradication campaigns.

In the Mediterranean region, at least in Spain, and in South Africa, the fly may be ignored so far as vegetables are concerned. The tomato, in which the fly will readily eviposit in the laboratory, was not found infested anywhere and none were seen in any market.

The stage when the host is susceptible to attack is important. Except under forced conditions the fruit must reach a certain stage of maturity. The orange must show some yellowing. The peach is not attacked while still hard and green but eggs will be found in this fruit at a greener stage than in most others. A few of the prevailing crop of oranges were found infested at Valencia on the 22nd of September. The time of attack of early fruits, as the loquat and apricot, under conditions at Valencia, is dependent upon the appearance of the fly for the summer. Loquats were mature late in April and apricots by May 18th yet there was no infestation in these fruits at Valencia at least up to May 23d. This fairly short season of susceptibility to attack at maturity greatly simplifies the control problem.

Seasonal History.

The seasonal history of the fly varies greatly within its distribution range, depending upon conditions of temperature. It is active the year round in Egypt and Hawaii. At Valencia, Spain, it disappears for the winter about January 1st. It reappears about June 1st. There is thus a quiescent period of five months. In the cooler parts of its range the active season is no doubt much shorter than the seven-months' period of Valencia. At the latter place one month might be deducted from the active season if activity means also breeding. An unsuspected fact was determined at Valencia last December that altho the adults are about there was no egg-laying. After Dec. 1st or the first week in December the flies simply carried over until January without breeding. And, judging from the records in my insectary, adults may emerge in mid-winter which undoubtedly die off without leaving progeny. In a steam-heated room in the hotel at Valencia adults emerged from the pupae on January 2nd. In an outdoor exposure corresponding pupae went into February before transforming. In a cooler situation several months more might be added to the pupal stage. I think the winter is passed chiefly in the puparium, and that such flies as might be occasionally seen in the winter season may be accounted for thru recent emergence, as was the case in my insectary.

Economic Importance.

There are two factors that markedly determine the economic importance of the fruit fly, namely, climatic conditions and sequence of host fruits. The breeding season of the fly as depending upon temperature varies from three, or at most four, months to twelve months. If there is a sequence of fruits for the twelve months and there are 15 generations in the same time it is not difficult to speculate on the population. On the other hand if the fly is inactive for a half or two-thirds of the year and at the end of that period it starts, as it does, with a low population, the increase is checked before it is well started. In April and May in the

Valencia section of Spain, for instance, there are many hundreds of acres of orange trees still carrying their full quota of mature fruit, yet not one of these are attacked because the fly has not appeared from its winter quarters. Contrast this with the situation in Florida last April when more than 500 flies were taken on one citrus tree at the same moment, and at another moment two days later there were more than 200 additional flies taken on the same tree.

If we may picture a situation which is favorable for the fly throughout the year and there is but a single host that may be susceptible to attack for but two months, there would be but two generations, and there would necessarily be a heavy mortality during the other ten months, so that each season would start with a very low population and there would not be time for a very great increase. From this exaggerated condition there are varying degrees of it occurring naturally, and this lack of host sequence constitutes the other check on the fly population.

The growing of peaches is undoubtedly restricted in many areas because of the fly. Peaches could otherwise be grown successfully in much of the fly area, particularly the cooler parts of it. But in the warmer parts of the fly area peaches would not be successful anyway. Hawaiian, Floridian and Egyptian conditions are not suitable to the peach. Southern California is less suitable for the peach than central and northern California. Some winters are so mild in southern California as to cause seriously delayed foliation in the peach. In any consideration of the restricted growing of a particular fruit in the fly area, therefore, other limiting factors should receive attention.

I have estimated that the infestation in oranges in Spain is about 1%. This occurs chiefly in October and November. The orange-harvesting season in Spain begins November 1st and ends June 1st. Such summer maturing oranges as occur are seriously infested. Losses also occur in loquats, in apricots, and to some extent in pears. Several other fruits are occasionally infested.

Horticultural Development and Practices.

Most of the fruits which are suitable to be grown in the Mediterranean area are grown there, so far as I can determine, with the exception of the peach, which might be grown more extensively were it not for the fly. This may apply to summer maturing oranges. I am not familiar with the status of the table grape industry in Spain. It is possible that the plantings of the Almeria grape would be extended were it not for the United States embargo on that fruit on account of the fly. I did not learn of any horticultural practice that was related to the destruction of the fly in any of its stages, in the Mediterranean region. Neither is there any disposition made of infested fruits or of noneconomic host plants.

In South Africa the situation is quite different. The highest quality of peach is grown in spite of the fly. The greatest care is taken in the frequent picking up of fallen fruit, and, in the case of oranges, in addition to the fallen fruits the prematurely colored fruits were seen to be picked off in some places. The false codling moth, Argyroploce leucotreta Meyr., is one of the important pests of the orange in South Africa, and it is a common cause of premature coloring. Picking such fruit off the

trees and destroying it not only destroys the false codling moth but it also prevents infestation of the fruit fly, or destroys it if it is already infested. No fruit is allowed to accumulate either in the orchard or about the packing houses, and all infested fruits are properly disposed of. There was no destruction of noneconomic host plants seen but in one place this was being considered in connection with the prickly pear. In a few places there was complaint that the neighbor was neglecting spraying and picking up fruit, and one or two cases where the neighbor's neglected trees were treated to protect the adjoining property.

Marketing and Handling.

Little consideration is given to infested fruits in the Mediterranean region, excepting some culling out of the infested fruits for the better markets. The poorer classes eat the good part of infested fruits, and it is only the badly broken down fruits that are a complete loss. There seem to be no restrictions regarding the tolerance of infested fruits on the markets or on fruit shipments.

In South Africa infested fruits are carefully culled out, particularly those for export. When the fruit reaches the precooling plant at Capetown three percent of it is inspected, that is, in 100 boxes 3 boxes are selected at random by a man who is not an inspector. Every fruit in these boxes is inspected and there must not be more than 5% of blemishes of all sorts, wrong variety, under size or weight, etc., otherwise the entire shipment is rejected. If but one fruit is found with a fly the box is rejected. Very few fly-infested fruits reach the precooling plant because every precaution must be taken to get the fruit started in a sound condition to minimize losses in the final markets.

Parasites.

No attempt was made to recover parasites in any of the places visited and little was learned second hand. Parasites seemed to be of little consequence. Silvestri stated that he thought parasites were responsible for checking the fly in the tropics, but not in the cooler parts of the fly zone. He had repeatedly tried to colonize them in Sicily and northern Africa but without success. He claimed the fly had a much greater climatic range than its parasites and much of the area was too cold for the parasites

Control.

Practically no control work is done against the fly in many of the Mediterranean countries. Traps were seen in some trees near Syracuse in Sicily and limited trapping is practiced at the agricultural school at Burajot near Valencia. Knap-sack sprayers were seen in operation in one orange grove in Egypt. Bait spraying had been employed by Borg in Malta, but he claimed it was not effective, and he was using carbon disulphide to kill the pupae in the soil; 10,691 citrus trees and 658 other fruit trees were thus treated in 1926-1927, with what he pronounced as quite satisfactory results.

In South Africa the poison spray is very generally employed and for the most part with results satisfactory to the growers, the most enthusiastic

of whom were in the western Cape. The fly may not be quite so troublesome here because it is the coolest part of the Union and also it is in the winter rainfall area, while the rest of the country has the rain in summer when the fly is active and the spray may be washed off. The regular Mally formula is used and it is carried about in buckets or 5-gallon oil tins, from which it is taken up in a large syringe and thus applied to the tree in two or three places. The syringe throws a rather coarse spray and spreads it widely so that a large part of the tree is covered. This spray has been found to be entirely ineffective at Cedara, Natal, by Ripley as a control for the Natal fly, Pterandrus rosa. For an account of this species see p. 7.

